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Solar Energy

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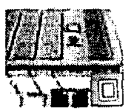

5 items

Article Outline

I INTRODUCTION

print section

Solar Energy, radiation produced by nuclear fusion reactions deep in the Sun's core (*see* Nuclear Energy). The Sun provides almost all the heat and light Earth receives and therefore sustains every living being.

Solar energy travels to Earth through space in discrete packets of energy called photons (*see* Electromagnetic Radiation) . On the side of Earth facing the Sun, a square kilometer at the outer edge of our atmosphere receives 1,400 megawatts of solar power every minute, which is about the capacity of the largest electric-generating plant in Nevada. Only half of that amount, however, reaches Earth's surface. The atmosphere and clouds absorb or scatter the other half of the incoming sunlight. The amount of light that

reaches any particular point on the ground depends on the time of day, the day of the year, the amount of cloud cover, and the latitude at that point. The solar intensity varies with the time of day, peaking at solar noon and declining to a minimum at sunset. The total radiation power (1.4 kilowatts per square meter, called the solar constant) varies only slightly, about 0.2 percent every 30 years. Any substantial change would alter or end life on Earth.

II INDIRECT COLLECTION

print section

People can make indirect use of solar energy that has been naturally collected. Earth's atmosphere, oceans, and plant life, for example, collect solar energy that people later extract to power technology.

The Sun's energy, acting on the oceans and atmosphere, produces winds that for centuries have turned windmills and driven sailing ships (*see* Wind Energy). Modern windmills are strong, light, weather-resistant, aerodynamically designed machines that produce electricity when attached to generators.

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Approximately 30 percent of the solar power reaching Earth is consumed by the continuous circulation of water, a system called the water cycle or hydrologic cycle.

The Sun's heat evaporates water from the oceans. Winds transport some of the water vapor from the oceans over the land where it falls as rain. Rainwater seeps into the ground or collects into streams or lakes and eventually returns to the ocean. Thus, radiant energy from the Sun is transformed to potential energy of water in streams and rivers. People can tap the power stored in the water cycle by directing these flowing waters through modern turbines. Power produced in this way is called hydroelectric power. See Waterpower; Dam.

The oceans also collect and store solar energy. A significant fraction of the Sun's radiation reflects or scatters from the water's surface. The remaining fraction enters the water and rapidly diminishes with depth as the energy is absorbed and converted to heat or chemical energy. This absorption creates differences in temperature between layers of water in the ocean called temperature gradients. In some locations, these differences approach 20°C (36°F) over a depth of a few hundred meters. These large masses of water existing at different temperatures create a potential for generating power. Energy flows from the high-temperature water to the low-temperature water (*see* Thermodynamics). The flow can be harnessed, to turn a turbine to produce electricity for example. Such systems, called ocean thermal energy conversion (OTEC) systems, require enormous heat exchangers and other hardware in the ocean to produce electricity in the megawatt range. Almost all of the major United States OTEC experiments in recent years have taken place in Hawaii.

Plants, through photosynthesis, convert solar energy to chemical energy, which fuels plant growth. People, in turn, use this stored solar energy through fuels such as wood, alcohol, and methane that are extracted from the plant life (biomass). Fossil fuels such as oil and coal are derived from geologically ancient plant life. People also eat and digest plants, or animals fed on plants, to obtain energy for their bodies.

III DIRECT COLLECTION OF SOLAR ENERGY

print section

People have devised two main types of artificial collectors to directly capture and utilize solar energy: flat plate collectors and concentrating collectors. Both require large surface areas exposed to the Sun since so little of the Sun's energy reaches Earth's surface. Even in areas of the United States that receive a lot of sunshine, a collector surface as big as a two-car garage floor is needed to gather the energy that one person typically uses during a single day.

A Flat Plate Collectors

Flat plate collectors are typically flat, thin boxes with a transparent cover that are mounted on rooftops facing the Sun. The Sun heats a blackened metal plate inside the box, called an absorber plate, that in turn heats fluid (air or water) running through tubes within the collector. The energy transferred to the carrier fluid, divided by the total solar energy that falls on the collector, is called the collector efficiency. Flat plate collectors are typically capable of heating carrier fluids up to 82°C (180°F). Their efficiency in making use of the available energy varies between 40 and 80 percent, depending on the type of collector.

These collectors are used for water and space heating. Homes employ collectors fixed in place on roofs. In the Northern Hemisphere, they are oriented to face true south (± 20°); in the Southern Hemisphere, they are oriented to face north. For year-round applications such as providing hot water, they are tilted relative to the horizontal at an angle equal to the latitude ± 15°.

In addition to the flat plate collectors, typical hot-water and space heating systems include circulating pumps, temperature sensors, automatic controllers to activate the circulating pump, and a storage device. Either air or a liquid (water or a water-antifreeze mixture) can be used as the fluid in the solar heating system. A rock bed or a well-insulated water storage tank typically serves as an energy storage medium.

B Concentrating Collectors

For applications such as air conditioning, central power generation, and many industrial heat requirements, flat plate collectors cannot provide carrier fluids at high enough temperatures to be effective. They may be used as first-stage heat input devices; the temperature of the carrier fluid is then boosted by other conventional heating means. Alternatively, more complex and expensive concentrating collectors can be used. These devices reflect the Sun's rays from a large area and focus it onto a small, blackened receiving area. The light intensity is concentrated to produce temperatures of several hundred or even several thousand degrees Celsius. The concentrators move to track the Sun using devices called heliostats.

Concentrators use curved mirrors with aluminum or silver reflecting surfaces that coat the front or back surfaces of glass or plastic. Researchers are developing cheap polymer films to replace the more expensive glass. One new technique uses a pliable membrane stretched across the front of a cylinder and another across the back with a partial vacuum between. The vacuum causes the membranes to form a spherical shape ideal for concentrating sunlight.

Concentrating solar energy is the least expensive way to generate large-scale electrical power from the Sun's energy and therefore has the potential to make solar power available at a competitive rate. Consequently, government, industry, and utilities have formed partnerships to reduce the manufacturing costs of concentrators.

One important high-temperature application of concentrators is solar furnaces. The largest of these, located at Odeillo in the Pyrenees Mountains of France, uses 63 mirrors with a total area of approximately 2,835 sq m (about 30,515 sq ft) to produce temperatures as high as 3200°C (5800°F). Such furnaces are ideal for research requiring high temperatures and contaminant-free environments—for example, materials research to determine how substances will react when exposed to extremely high temperatures. Other methods of reaching such temperatures usually require chemical reactants that would also react with the substances to be studied, skewing the results.

Another type of concentrator called a central receiver, or "power tower," uses an array of sun-tracking reflectors mounted on computer-controlled heliostats to reflect and focus the Sun's rays onto a water boiler mounted on a tower. The steam thus generated can be used in a conventional power-plant cycle to produce electricity. A U.S. demonstration in the Mohave Desert, Solar One, operated through most of the 1980s. During the early 1990s a second demonstration, called Solar Two, used molten salt heated in the boiler to 574°C (1065°F) to produce electricity. The hot salt was stored and later used to boil water into steam that drove a turbine to produce electricity.

IV PASSIVE SOLAR HEATING

print section

The solar energy that falls naturally on a building can be used to heat the building without special devices to capture or collect sunlight. Passive solar heating makes

use of large sun-facing windows (south-facing in the Northern Hemisphere) and building materials such as brick and tile that absorb and slowly release solar heat. A designer plans the building so that the longest walls run from east to west, providing lengthy southern exposures that allow solar heat to enter the home in the winter. A well-insulated building with such construction features can trap the Sun's energy and reduce heating bills as much as 50 percent. Passive solar designs also include natural ventilation for cooling. Shading and window overhangs also reduce summer heat while permitting winter Sun.

In direct gain, the simplest passive heating system, the Sun shines into the house and heats it up. The house's materials store the heat and slowly release it. An indirect gain system, by contrast, captures heat between the Sun and the living space, usually in a wall that both absorbs sunlight and holds heat well. An isolated gain system isolates the heated space (a sunroom or solar greenhouse, for example) from the living space and allows the solar heat to flow into the living area via convective loops of moving air.

V SOLAR COOLING

print section

Solar energy can also be used for cooling. An absorption air conditioner or refrigerator uses a large solar collector to provide the heat that drives the cooling process (*see* Refrigeration). Solar heat is applied to the refrigerant and absorbent mixture, which is combined under pressure in a container called a generator or boiler. The Sun's heat brings the mixture to a boil. The refrigerant (often ammonia) vaporizes, rises as a gas, and reaches the condenser. There it gives off heat and returns to liquid form. As the drops of pure refrigerant fall, they trickle into the evaporator (freezing unit) where they evaporate vigorously. Evaporation requires heat energy, which comes from the surroundings, and results in cooling: The refrigerant absorbs heat from the unit and cools the space. The refrigerant, now a gas again, rejoins the mixture in the boiler to restart the process.

Absorption coolers must be adapted to operate at the normal working temperatures for flatbed solar collectors—between 82° and 121°C (180° and 250°F) Alternatively, concentrating collectors may be used.

VI PHOTOVOLTAICS

print section

Solar cells called photovoltaics made from thin slices of crystalline silicon, gallium arsenide, or other semiconductor materials convert solar radiation directly into electricity. Cells with conversion efficiencies greater than 30 percent are now available. By connecting large numbers of these cells into modules, the cost of photovoltaic electricity has been reduced to 20 to 30 cents per kilowatt-hour. Americans currently pay 6 to 7 cents per kilowatt-hour for conventionally generated electricity.

The simplest solar cells provide small amounts of power for watches and calculators. More complex systems can provide electricity to houses and electric grids. Usually though, solar cells provide low power to remote, unattended devices such as buoys, weather and communication satellites, and equipment aboard spacecraft.

VII SOLAR ENERGY FROM SPACE

print section

A futuristic proposal to produce power on a large scale envisions placing giant solar modules in geostationary Earth orbit. Energy generated from sunlight would then be converted to microwaves and beamed to antennas on Earth for conversion to electric power. The Sun would shine on a solar collector in geostationary orbit almost 24 hours a day; moreover, such a collector would be high above the atmosphere and so would receive the full power of the Sun's rays. Consequently, such a collector would gather eight times more light than a similar collector on the ground. To produce as much power as five large nuclear power plants (1 billion watts each), several square miles of solar collectors, weighing 10 million pounds, would need to be assembled in orbit. An Earth-based antenna five miles in diameter would be required to receive the microwaves. Smaller systems could be built for remote islands, but the economies of scale suggest advantages to a single large system (*see* Space Exploration).

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L7   ANSWER 5 OF 14 CAPLUS COPYRIGHT 2003 ACS
AN   1995:767686 CAPLUS
DN   123:148976
TI   Conversion of **solar energy** stored in plants to diesel fuel
IN   Winkelkoetter, Peter
PA   Beulen, Wolfgang, Germany
SO   Ger. Offen., 6 pp.
     CODEN: GWXXBX
DT   Patent
LA   German
IC   ICM C10L009-00
     ICS C10L001-14; C12P007-04; C05F005-00; C10L005-44; F24J002-00; F03G006-00; C02F011-04
ICA A23K001-00; C07K015-00; C12N009-00; C11B001-00
CC   52-1 (Electrochemical, Radiational, and Thermal Energy Technology)
     Section cross-reference(s): 60
FAN.CNT 1

	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
PI	DE 4402559	A1	19950803	DE 1994-4402559	19940128
	DE 4402559	C2	19951123		
PRAI	DE 1994-4402559		19940128		

AB   Biomass is distd. to alc., wood is distd. to produce tar, and oil is expressed from seeds such as rapeseed. The 3 streams are mixed to form a diesel fuel suitable for generation of thermal and elec. power. The wastes from these process are further processed to form biogas, tar, acetic acid, tar, and **charcoal**. Slaughterhouse waste and other biomass waste are composted together to form soil amendments. The wastewaters from all these processes are biol. treated and the solids are composted.
ST   biomass conversion diesel fuel
IT   Biomass
     Compost
     Fuels, diesel
     Plant
     Power
     Soil amendments
     Solar energy
     Wastes
     Wastewater
     Wood
        (conversion of **solar energy** stored in plants to diesel fuel and other products)
IT   Alcohols, preparation
     Charcoal
     Tar
     RL: IMF (Industrial manufacture); PREP (Preparation)
        (conversion of **solar energy** stored in plants to diesel fuel and other products)
IT   Fats and Glyceridic oils
     RL: RCT (Reactant); RACT (Reactant or reagent)
        (conversion of **solar energy** stored in plants to diesel fuel and other products)
IT   Rape (plant)
        (seed; conversion of **solar energy** stored in plants to diesel fuel and other products)
IT   Fuel gases
     RL: IMF (Industrial manufacture); PREP (Preparation)
        (biogas, conversion of **solar energy** stored in plants to diesel fuel and other products)

4 MM 20

IT Wastes
(slaughterhouse, conversion of **solar energy** stored in plants to diesel fuel and other products)
IT Tar
RL: IMF (Industrial manufacture); PREP (Preparation)
(wood, conversion of **solar energy** stored in plants to diesel fuel and other products)
IT 64-19-7P, Acetic acid, preparation
RL: IMF (Industrial manufacture); PREP (Preparation)
(conversion of **solar energy** stored in plants to diesel fuel and other products)

```
L7   ANSWER 4 OF 14  CAPLUS  COPYRIGHT 2003 ACS
AN   1996:743570  CAPLUS
DN   126:10017
TI   Process and device for energy production from renewable raw materials
IN   Winkelkoetter, Peter
PA   Winkelkoetter, Peter, Germany
SO   PCT Int. Appl., 24 pp.
     CODEN: PIXXD2
DT   Patent
LA   German
IC   ICM  C10L001-00
CC   52-1 (Electrochemical, Radiational, and Thermal Energy Technology)
     Section cross-reference(s): 51
FAN.CNT 1
     PATENT NO.        KIND  DATE           APPLICATION NO.  DATE
     ---------------   ----  --------       ---------------  --------
PI   WO 9632460         A1   19961017       WO 1995-EP1365   19950412
         W:  CN, JP, SG, US, VN
         RW: KE, MW, SD, SZ, UG, AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT,
             LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE,
             SN, TD, TG
PRAI WO 1995-EP1365          19950412
AB   A process is disclosed for converting vegetable-bound solar
     energy, for achieving a high degree of efficiency and for creating
     an ecol. and economically compatible system characterized by the assocn.
     of product manufg. and energy prodn. lines.  The byproducts of the manufg.
     steps represent energy carriers and are converted in a central energy
     prodn. plant into thermal and elec. energy that can in turn be used to
     carry out the manufg. steps.
ST   energy prodn renewable raw material; charcoal energy prodn;
     biomass energy prodn; plant oil energy prodn; alc energy prodn
IT   Biomass
        (energy prodn. from renewable raw materials)
IT   Alcohols, processes
       Charcoal
     Fats and Glyceridic oils, processes
     RL: PEP (Physical, engineering or chemical process); PROC (Process)
        (energy prodn. from renewable raw materials)
IT   Diesel fuel
     Energy
        (prodn. from renewable raw materials)
```